(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 September 2002 (19.09.2002)

PCT

(10) International Publication Number
WO 02/073852 A2

(51) International Patent Classification[7]: H04J 13/00

(21) International Application Number: PCT/CA02/00310

(22) International Filing Date: 7 March 2002 (07.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/274,612 12 March 2001 (12.03.2001) US

(71) Applicant: MERITON NETWORKS INC. [CA/CA]; 3026 Solandt Road, Ottawa, Ontario K2K 2A5 (CA).

(72) Inventors: LIU, Ling-Zhong; 1053 Alenmede Cres., Ottawa, Ontario K2B 8H2 (CA). XU, Jim, Jincheng; 6 Bon Echo Cres., Kanata, Ontario K2M 2W5 (CA). ASQUIN, Donald; 47 Leonard Avenue, Ottawa, Ontario K1S 4T8 (CA).

(74) Agent: MACGREGOR, George; c/o Marks & Clerk, Suite 1800, 280 Slater Street, Ottawa, Ontario K1P 1C2 (CA).

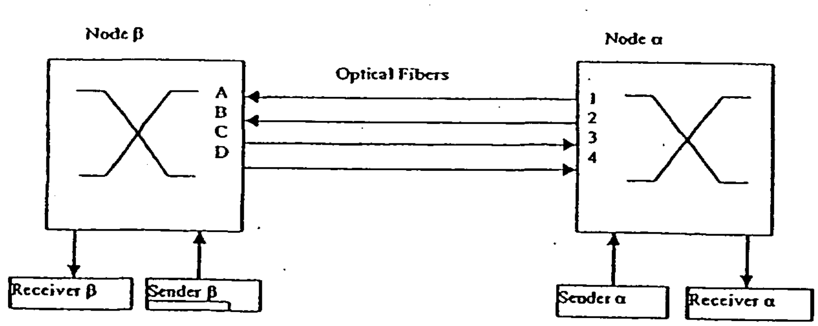
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS AND METHOD FOR AUTOMATED FIBER CONNECTION DISCOVERY AND DIAGNOSTICS



a diagram of two optical nodes connected with a bundle of optical fibers

(57) Abstract: The invention proposes an apparatus and method to automatically discover port mapping between neighboring optical nodes in a switched optical network. It can also be used as a diagnostic method to find faulty connections and channels. It is assumed that each node has a switch that can connect any ingress port to any egress port in the node.

WO 02/073852 A2

BEST AVAILABLE COPY

Apparatus and Method for Automated Fiber Connection Discovery and Diagnostics

[0001] This invention claims the benefit of U.S. Provisional Application No. 60/274,612 filed March 12, 2001.

Field Of The Invention:

[0002] This invention relates to communications systems and more particularly to the network management of communications systems involving switched optical networks.

Background

[0003] In a switched optical network, typically, two neighboring nodes are physically connected by a bundle of optical fibers. At each node, each optical fiber within the bundle is identified as a port and assigned a unique port number. When two nodes are interconnected by optical fibers, it is necessary to make sure that the ports in one node are mapped to the ports in the other node as required. There is a possibility that some optical fibers are incorrectly connected to the wrong ports. It is also possible that there are some connection failures or faults. Accordingly there is a need for a system to automatically discover fiber connections in a switched optical network. Also, the discovery mechanism can, preferably, provide a diagnostic function.

Summary of the Invention

[0004] The present invention provides an apparatus and method for automatically discovering port mapping. It can also be used as a diagnostic method to find faulty

connections and channels. In the following description it is assumed that each node has a switch that can connect any ingress port to any egress port in the node. The system employs a handshaking protocol comprising a series of discovery and acknowledgement messages. Additionally, once the ports have established connectively, performance testing can determine the quality of the connection.

[0005] According to a broad aspect of the invention there is provided a handshaking protocol to automatically discover fiber connections in a switched optical network and to provide diagnostics for fault connections on two neighboring optical nodes.

Brief Description of the Drawings

[0006] The invention will now be described in greater detail with reference to the attached drawings wherein:

[0007] Figure 1 is a diagram of two optical nodes connected by a bundle of optical fibers;

[0008] Figure 2 illustrates a handshaking sequence;

[0009] Figure 3 is a flow diagram of the algorithm implemented on the receiving node;

[0010] Figure 4 is a flow diagram of the algorithm implemented on the sending node;

[0011] Figure 5 illustrates the message format for connect, reply and confirmation;

[0012] Figure 6 is a diagram of two optical nodes connected with a bundle of optical fibers using a Bit Error Rate Test Set (BERTS) to determine quality of the connection; and

[0013] Figure 7 is a diagram of two optical nodes driven by a specific Synchronous Optical Network (SONET) payload to determine the quality of the connection.

Detailed Description of the Invention

[0014] In a switched optical network as contemplated by the present invention, two neighboring nodes are physically connected by a bundle of optical fibers. At each node, individual fibers are identified as a port and are assigned a port number. It is, of course, desirable to make sure that each port in one node is mapped to a connected port in the other node.

[0015] Figure 1 shows the basic concept of two nodes α and β connected by a bundle of fibers. Each node has several ingress ports and several egress ports, numbered 1, 2, 3, 4, A, B, C and D in Figure 1. In this exemplary embodiment two ingress ports and two egress ports are shown for each node. It is to be understood that in a practical implementation there will be many of each type of nodes. It is possible that an ingress port is paired with an egress port, and the two ports are assigned to the same port number. However the invention is independent in relation to the numbering scheme as long as the scheme can uniquely identify each port.

[0016] Each egress port is physically connected to an ingress port of its neighboring node by an optical fiber. In the following discussion these ports are known as a Connection Port Pair (CPP). The discovery function, according to the invention, is to find the CPP pair for each port in a node. In the invention, port-mapping

discovery is performed by exchanging Connection Discovery Messages (CDM) between the two CPP ports.

[0017] In a Wavelength Division Multiplex (WDM) system, there may be multiple wavelengths transported through a single fiber. However, to discover the mapping for each CPP, only one wavelength is needed for exchanging CDMs. A default wavelength is defined and agreed upon by all nodes for exchanging the CDMs. Normally the longest wavelength is chosen and is called a CDM channel.

[0018] The connection discovery process is triggered by an operator. The operator may initiate the discovery process for all the fiber ports, or only some specified ports inside the node. Once the process starts, the node begins to send the CDMs to all or some of its specified egress port using the CDM channels. Additionally, each node has a receiver that is connected to each of its specified ingress ports to wait for a CDM on the CDM channels. A rotation or scanning mechanism to scan all specified ingress and egress ports is described later.

[0019] The CDM format includes the node name and the sending port number. Once a node receives a CDM, it embeds its node name, receiving port and reply or send port numbers, together with the originator's sending port number into the reply CDM and sends back the reply message. When this reply message reaches the original sender, the original sender knows which pair of the fibers is connected to it. It then sends back the reply CDM through its original sending port. This reply CDM embeds additional receiving port number information. When the other node receives this CDM, it knows which pair of the fibers is connecting to it as well. It then sends back a reply CDM to the sender to let the sender know that it knows the connections. The original sender replies to this CDM to let the original receiver know that it also knows the connections. The receiver then sends back a reply CDM to finish the handshaking procedure.

[0020] The detailed handshaking algorithm and the message format will now be described.

1. The Handshaking protocol

[0021] Each node sends and receives the CDMs by connecting the spare monitoring channels to its egress or ingress ports via its switching fabric. The sending unit sends out the CDMs to each of its specified egress port and the receiver unit monitors the reply CDMs on each of its specified ingress ports. As an example, the handshaking algorithm for the system in Figure 1 may work as following:

1) Sender α: sends out α1000 through port 1, which means the message comes from node α port 1 searching for its connected port.

2) Receiver β: receives α1000 on port A. It knows that its port A is connected to port 1 of the node α.

3) Sender β: sends out βC0A1 through port C.

4) Receive α: receives βC0A1 from port 3. Node α then knows that its port 1 is connected to port A of the node β and its port 3 is connected to port C of the node β.

5) Sender α: sends α1A3C through port 1 to node β.

6) Receiver β:receives α1A3C from port A. Node β then knows that its port A is connected to port 1 of the node α and its port C is connected to port 3 of the node α. It also knows that the node α already knows these connections.

7) Sender β: sends out βC3A1 through port C to node α.

8) Receiver α: receives βC3A1 from port 3. Node α then knows that node β knows the connection as well.

9) Sender α: sends α1A3C through port 1 to node β for confirmation.

A) Receiver β: receives α1A3C from port A. Receiver β knows that node α is requiring confirmation.

B) Sender β: sends out βC3A1 through port C to node α for confirmation and updates node β's connection mapping table.

C) Receiver α: receives βC3A1 from port 3, and updates node α's connection mapping table.

[0022] To avoid missing CDMs, the sender at each node preferably scans each of its specified egress port at a relatively fast speed. On the other hand, the receiver at each node should scan each of its specified ingress port at a slower speed. At least the receiver should stay monitoring one ingress port until the sender has finished scanning all of its egress ports.

[0023] Once a receiver receives a CDM, the node should stop scanning the egress port to send CDMs. It should focus on replying to the CDM. On the other hand, once a sender receives a reply CDM, it should stop scanning and focus on dealing with this reply CDM until a connection is confirmed or timed out.

[0024] If in step 6) above the receiver β cannot obtain the acknowledgement CDM from node α, it knows that the reply channel has something wrong. Node β should choose another egress port to send out an error message to node α. It should also raise an alarm showing this egress port error.

[0025] If in step 4) the receiver α cannot receive a reply CDM after a certain amount of time, it should raise an alarm showing the connection error.

[0026] Figure 2 shows the handshaking algorithm. The algorithm can be summarized using the flowcharts shown in Figures 3 and 4. Both the sending and receiving algorithms may run on the two neighboring nodes. Once a node is

receiving a CDM, it will focus on the receiving algorithm and its peer node should focus on the sending algorithm. The node administrators/operators may also initiate one node to run the sending algorithm and the other one to run the receiving algorithm.

[0027] Once connectivity has been established, performance testing can be initiated to determine the quality of the connection. Figure 6 shows a Bit Error Rate Test Set (BERTS) 61, either internal or external, connected to Node β 63. The test pattern is routed through the node to an output port, in this case "D". The test pattern travels down the fiber 64 to the port on Node α 65, in this case "4". Node α 65 loops the signal back to one of its output ports, in this case "1", across the optical fiber 66 to Node β 63, in this case, port "A". The test pattern is routed through Node β back to the BERTS 61. The BERTS can determine the error rate of the looped back signal and indicate to the user if there is a problem with one of the components (Transmitter, Fiber, Receiver) the connection path.

[0028] Alternately a specific Synchronous Optical Network (SONET) payload can be used to determine the quality of the connection. Figure 7 shows an all 1's Line Alarm Indication Signal (AIS) 71 being multiplexed 73 with the SONET overhead and Line Bit Interleaved Parity 8 (BIP-8) 72. The resulting data pattern is scrambled in a 2^7-1 scrambler 74. The scrambled data can optionally have Forward Error Correction (FEC) added through a 1:2 Demultiplexer (Demux) 75, 1:2 Multiplexer (Mux) 78 and a FEC Encoder 76. Errors can be injected 77 into the FEC. The SONET Synchronous Transport Signal 48 (STS-48) is connected to Node β 79. The test pattern is routed through the node to an output port, in this case "D". The test pattern travels down the fiber 712 to the port on Node α 711, in this case "4". Node α 711 loops the signal back to one of its output ports, in this case "1", across the optical fiber 710 to Node β 79, in this case, port "A". The test pattern is routed through Node β 79. Optionally, FEC coding can be decoded and

FEC errors detected through a 1:2 Demultiplexer (Demux) 713, 1:2 Multiplexer (Mux) 715 and a FEC Decoder 714. The SONET frame is then Frame and Byte Aligned 716 and the Bit Error Rate (BER) detected through errors in the Line BIP-8 717. This can determine the error rate of the looped back signal and indicate to the user if there is a problem with one of the components (Transmitter, Fiber, Receiver) the connection path. Line BIP-8 is a standard method of error detection in a SONET network.

2. Connect Discovery Message (CDM) format

[0029] Figure 5 shows the message format for the connect requirement, reply and confirmation. The definition of each field is described as following:

1. Synchronization header.
2. Message type (e.g. discovery, reply, acknowledgement, confirmation, testing, error).
3. Node name which is sending this message.
4. Egress port number which is sending this message.
5. Ingress port number who should receive this message. 0 means do not know.
6. Ingress port number on the sending node which should receive the reply message. 0 means do not know.
7. Egress port number which should send back reply message. 0 means do not know.
8. Error checking field.

[0030] The following possible variation is contemplated by the invention:

[0031] The relationship of the two connected optical nodes may be varied such that the two nodes may run the same algorithm or one node may act as the master and the other node as slave.

[0032] A particular advantage of the invention is that it provides automatic discovery and diagnostics, and that it automatically provides performance testing between the two nodes.

[0033] While particular embodiments of the invention have been described and illustrated it will be apparent to one skilled in the art that numerous changes can be made without departing from the basic concept. It is to be understood that such changes will fall within the full scope of the invention as defined by the appended claims.

We Claim:

1. A method of automatically discovering port mapping between neighboring optical nodes in a switched optical network, the method employing a handshaking protocol between the nodes to discover fiber connections therebetween.

2. The method according to claim 1 wherein said handshaking protocol performs connection fault diagnostics.

3. The method according to claim 1 wherein said handshaking protocol includes the transfer of connection discovery messages.

4. The method according to claim 1 wherein said handshaking protocol is transferred between the nodes utilizing a dedicated wavelength channel.

5. The method according to claim 3 wherein said connection discovery messages include connected port pair (CPP) information.

6. The method according to claim 5 wherein said CPP information includes node name and port number.

7. The method according to claim 5 wherein said CPP information includes connection status information.

8. The method according to claim 5 wherein said CPP information includes diagnostic information.

9. The method according to claim 1 wherein a receiver unit at each node scans each specified ingress port for incoming connection discovery messages.

10. The method according to claim 9 wherein the receiving unit monitors an ingress port until a sender unit at the node finishes scanning of egress ports on the node.

11. A system for automatically discovering port mapping between neighbouring optical nodes in a switched optical network comprising a sender unit at each node for sending a connection discovery message to said other node, and a receiver unit at each node for receiving a connection discovery message for said other node, whereby connection port pair information is encoded into said messages.

12. The system according to claim 11 wherein said neighbouring optical nodes are interconnected via a bundle of optical fibers.

13. The system according to claim 12 wherein each node has a plurality of ports, with an optical fiber connecting ports on respective nodes.

14. The system according to claim 13 wherein each port has a port name and a unique port number.

15. The system according to claim 14 wherein each sender unit and each receiver unit sends and receives connection discovery messages over a message channel.

16. The system according to claim 15 wherein each node has scanning means to send messages to selected ports over said message channel.

17. The system according to claim 12 wherein said optical nodes have performance testing functionality to determine quality of the connection between said optical nodes.

18. The system according to claim 17 wherein said performance testing functionality is provided by a Bit Error Rate Test Set (BERTS).

19. The system according to claim 17 wherein said performance testing functionality is provided by a Synchronous Optical Network (SONET) pay load.

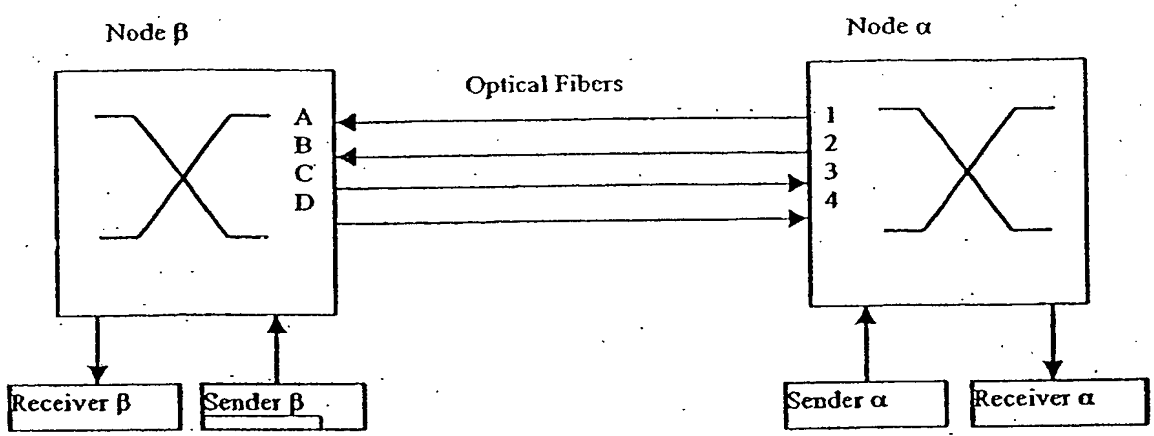


Figure 1 a diagram of two optical nodes connected with a bundle of optical fibers

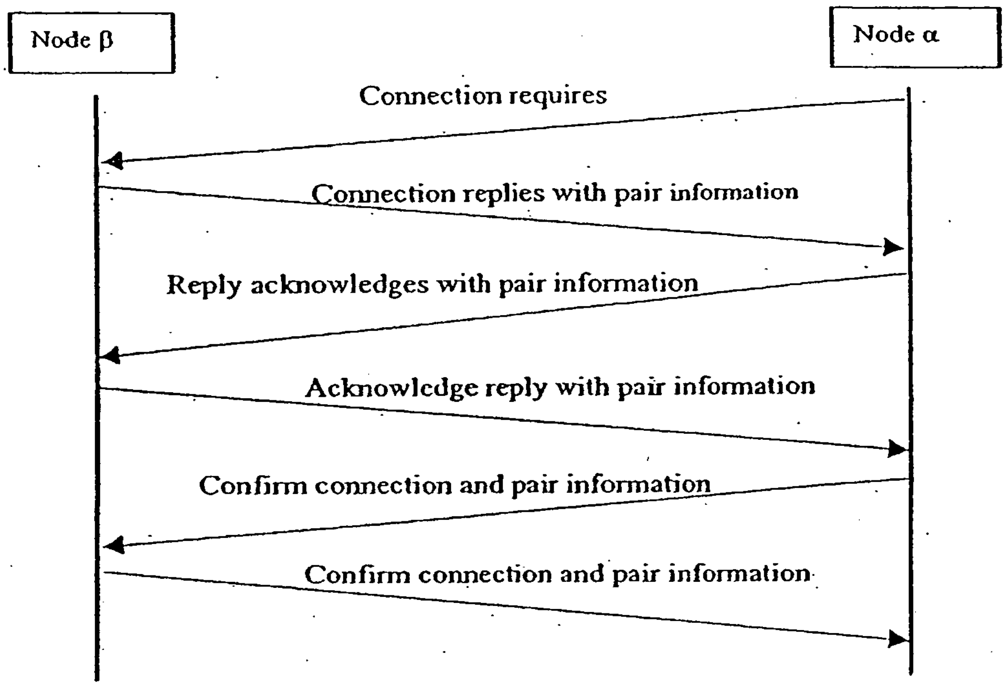


Figure 2 Handshaking protocol

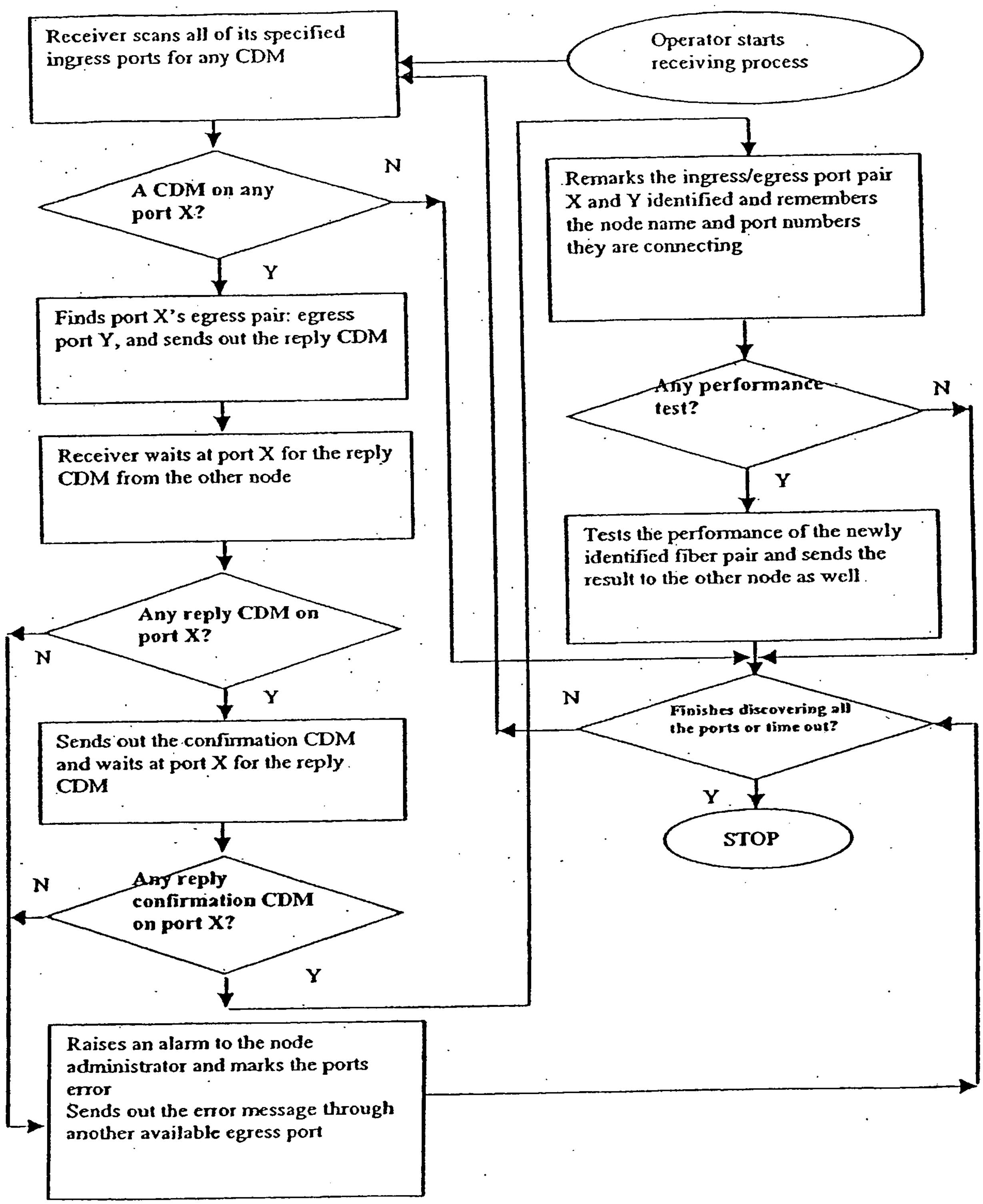


Figure 3 the algorithm on the receiving node

SUBSTITUTE SHEET (RULE 26)

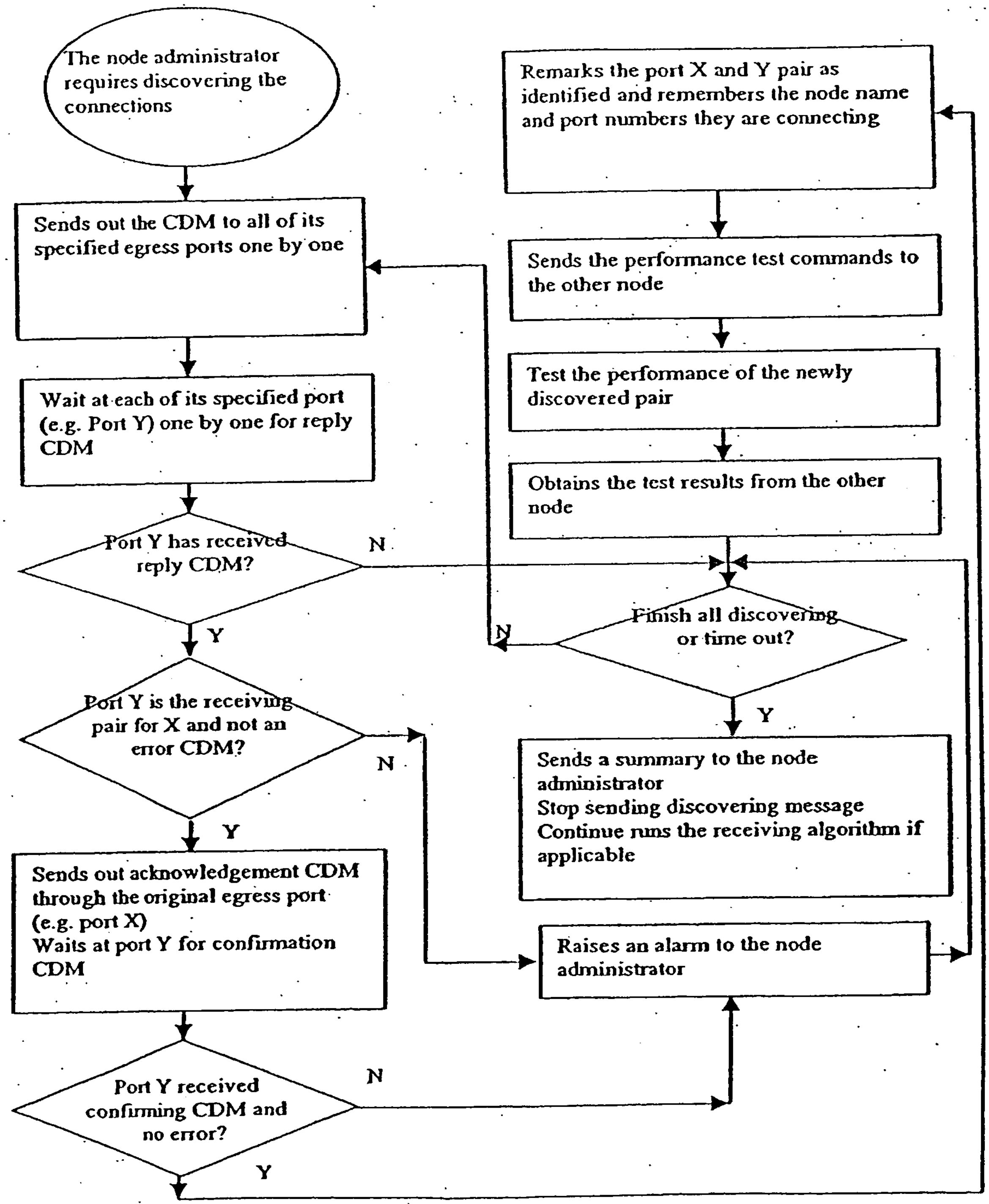


Figure 4 the algorithm on the sending node

1	2	3	4	5	6	7	8

Figure 5 Message format

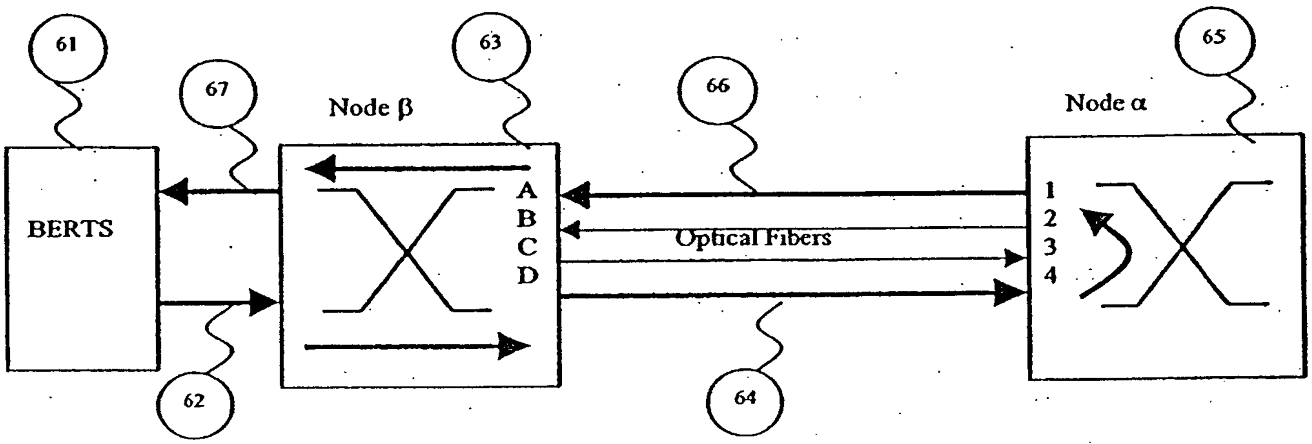


Figure 6 a diagram of two optical nodes connected with a bundle of optical fibers using a Bit Error Rate Test Set (BERTS) to determine quality of connection

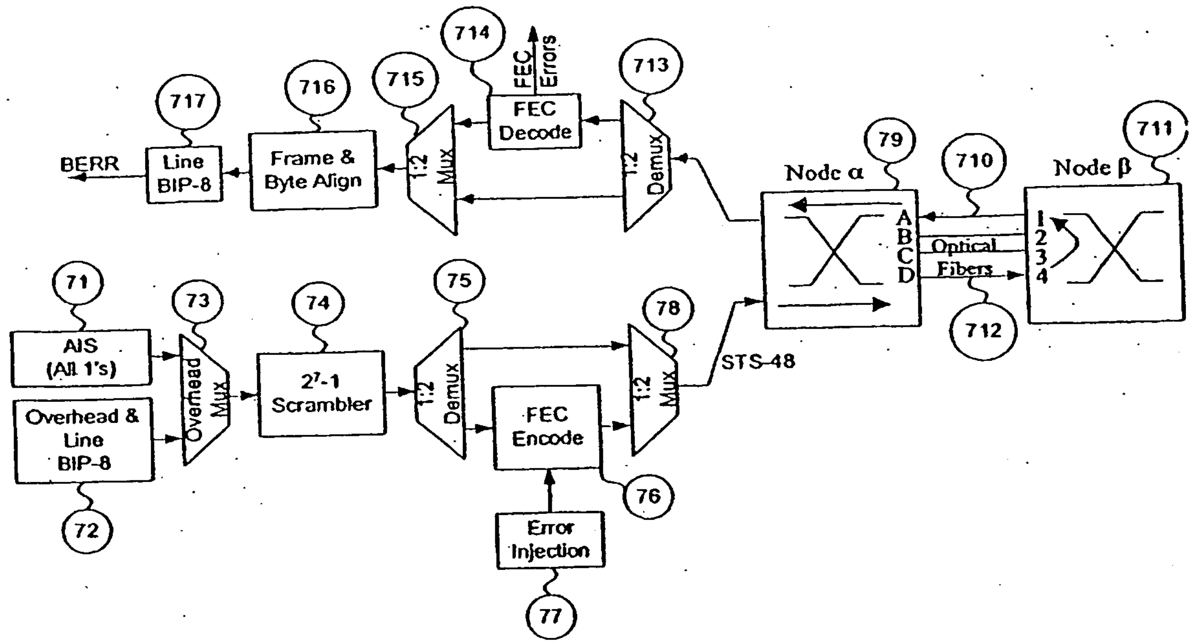


Figure 7 a diagram of two optical nodes driven by a specific Synchronous Optical Network (SONET) payload to determine the quality of the connection.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 September 2002 (19.09.2002)

PCT

(10) International Publication Number
WO 02/073852 A3

(51) International Patent Classification[7]: H04Q 11/00, H04L 12/56, H04Q 11/04

(21) International Application Number: PCT/CA02/00310

(22) International Filing Date: 7 March 2002 (07.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/274,612 12 March 2001 (12.03.2001) US

(71) Applicant: MERITON NETWORKS INC. [CA/CA]; 3026 Solandt Road, Ottawa, Ontario K2K 2A5 (CA).

(72) Inventors: LIU, Ling-Zhong; 1053 Alenmede Cres., Ottawa, Ontario K2B 8H2 (CA). XU, Jim, Jincheng; 6 Bon Echo Cres., Kanata, Ontario K2M 2W5 (CA). ASQUIN, Donald; 47 Leonard Avenue, Ottawa, Ontario K1S 4T8 (CA).

(74) Agent: MACGREGOR, George; c/o Marks & Clerk, Suite 1800, 280 Slater Street, Ottawa, Ontario K1P 1C2 (CA).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

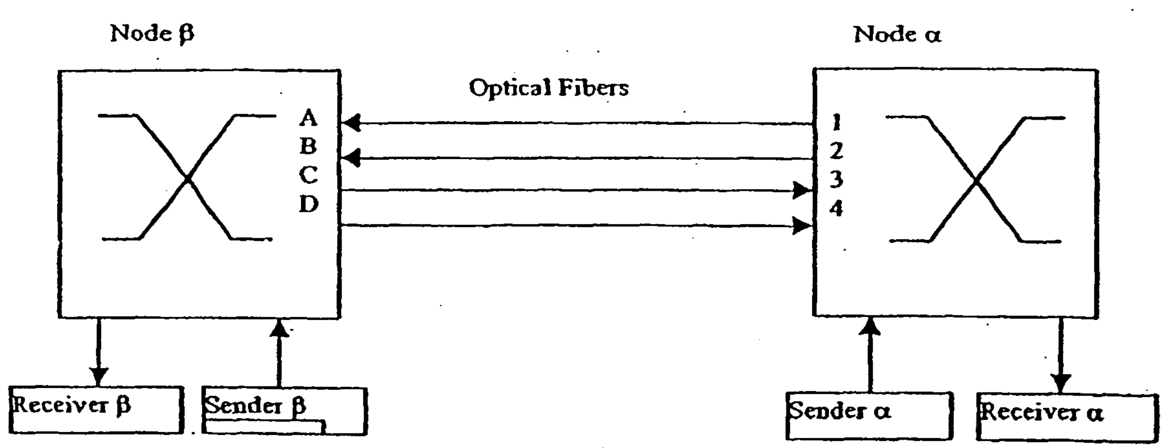
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report: 5 December 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS AND METHOD FOR AUTOMATED FIBER CONNECTION DISCOVERY AND DIAGNOSTICS



(57) Abstract: The invention proposes an apparatus and method to automatically discover port mapping between neighboring optical nodes in a switched optical network. It can also be used as a diagnostic method to find faulty connections and channels. It is assumed that each node has a switch that can connect any ingress port to any egress port in the node.

WO 02/073852 A3

INTERNATIONAL SEARCH REPORT

In ›nal Application No
PCT/CA 02/00310

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q11/00 H04L12/56 H04Q11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 847 830 A (MOMIROV MILAN) 11 July 1989 (1989-07-11) column 3, line 37 - line 65 ---	1-19
A	EP 0 752 795 A (IBM) 8 January 1997 (1997-01-08) column 3, line 20 - line 49 column 7, line 4 - line 35 column 8, line 25 -column 9, line 17 ---	1-19
A	US 5 687 168 A (IWATA ATSUSHI) 11 November 1997 (1997-11-11) column 1, line 31 - line 32 column 4, line 13 - line 30 column 4, line 46 - line 56 column 5, line 11 - line 17 column 5, line 42 - line 46 column 5, line 52 - line 57 --- -/--	1-19

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 October 2002	16/10/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Meurisse, W

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99 25101 A (ERICSSON TELEFON AB L M ;LENANDER JAN (SE)) 20 May 1999 (1999-05-20) page 13, line 5 - line 23 page 21, line 16 - line 22	1-19

INTERNATIONAL SEARCH REPORT
Information on patent family members

In ional Application No
PCT/CA 02/00310

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4847830	A	11-07-1989	AT	120919	T	15-04-1995
			AU	620063	B2	13-02-1992
			AU	2824089	A	05-07-1989
			CA	1307350	A1	08-09-1992
			DE	3853539	D1	11-05-1995
			DE	3853539	T2	14-12-1995
			EP	0396589	A1	14-11-1990
			JP	2834505	B2	09-12-1998
			JP	3502742	T	20-06-1991
			WO	8905551	A1	15-06-1989
EP 0752795	A	08-01-1997	US	5781537	A	14-07-1998
			EP	0752795	A2	08-01-1997
			JP	3090616	B2	25-09-2000
			JP	9036892	A	07-02-1997
			KR	228943	B1	01-11-1999
US 5687168	A	11-11-1997	JP	2723084	B2	09-03-1998
			JP	9036873	A	07-02-1997
			CA	2181425	A1	20-01-1997
WO 9925101	A	20-05-1999	SE	511823	C2	06-12-1999
			AU	1182199	A	31-05-1999
			EP	1034641	A2	13-09-2000
			SE	9704075	A	08-05-1999
			WO	9925101	A2	20-05-1999
			US	6401129	B1	04-06-2002

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.